BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B70 12026

SUBJECT: Sleep First Lunar Surface Timeline for Apollo 15 Case 320

DATE: December 11, 1970

FROM: P. Benjamin

ABSTRACT

A recently proposed Apollo 15 lunar surface timeline currently under consideration at MSC includes a top-hatch EVA (or IVA) shortly after touchdown. To provide time for the IVA, the lunar surface timeline would have to be modified to provide a rest period after the IVA and before EVA 1, rather than performing EVA 1 after landing and then sleeping, as is currently planned.

The IVA provides an extra hour of reconnaissance and photo documentation of 360° of the lunar surface from the LM, which may result in increased scientific return and may provide an opportunity for traverse modification based on observation of the terrain. A 180° view of the surface from 3 feet lower may be obtained through the LM windows. A 7 hour EVA 1 can be provided by the sleep first plan, providing an opportunity to attain some of the primary geologic objectives in the first EVA and perhaps permitting a visit to a possible volcanic constructional complex on EVA 3. The EVA 1 traverse would require riding to a point about 3 km away from the LM at the end of an EVA which is planned, for the first time, to be more than 5 hours long, and which would involve the first use of the -7 PLSS and the LRV.

Other factors which must be considered in the proposed sleep first plan are a long last surface day culminating in lift-off and rendezvous, loss of timeline flexibility to reschedule the final surface sleep period, degraded circadian rhythm, reduced length of rest periods, an extra depress/repress cycle, a shift of the EVA's from the day and evening (EST) to night and morning, and the delay of all EVA's and PC-2 by about 10 hours compared to the present plan. The scientific and planning advantages of an extra hour of reconnaissance from the top hatch of the LM and an extended EVA 1 must be weighed against the disadvantages which accrue.

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MEMORANDUM FOR FILE

It has recently been proposed that the Apollo 15 lunar surface timeline be modified to include a top-hatch EVA, sometimes called an IVA, shortly after landing. In this top-hatch EVA one crewman would stand on the ascent engine cover and survey the lunar surface from the top hatch of the LM for about 1 hour. Life support during the EVA would be supplied by the LM ECS. To accommodate the IVA, the lunar surface timeline would be modified to provide a rest period after the IVA and before EVA 1, rather than performing EVA 1 after landing and then sleeping, as is currently planned. The current EVA first and proposed IVA and sleep first timelines as constructed by MSC (1) are shown in Figure 1. Additional proposed changes to the sleep first timeline extend EVA 1 to 7 hours and reduce EVA 3 to 6 hours. The benefits and costs of the sleep first timeline are manifold, with a net outcome that is not decisive. An attempt is made here to discuss briefly some of the issues.

RATIONALE

The proposed change maintains the total surface EVA time and adds 1 hour of surface observation. From a scientific point of view this can only be a benefit. Clearly, the preliminary reconnaissance afforded by the IVA can contribute positively to the scientific return by providing the crew with an initial estimate of the lunar terrain in the vicinity of the LM. It provides an opportunity for a 360° photographic pan from a local high point, allows stereo documentation of the area close to the LM, and permits an early description of terrain and geology to earth-based planners. Also the crew have a chance to observe the terrain characteristics as they might affect the later EVA activities, which may be of use in modifying traverse plans.

A 180° view of the lunar surface can, however, be obtained from a point only 3 feet lower -- out the LM windows. This view can, additionally, be obtained without the consumables cost, timeline impact, and extra depress/repress required by the IVA. Thus 3 feet in extra elevation and an earlier view of 180° of the lunar surface may be regarded as the primary advantages of the IVA, and the value of this reconnaissance must be evaluated against the disadvantages of the total plan. Of course, both plans will provide surface and terrain data immediately upon beginning EVA 1.

WORK/REST CYCLES

The timeline impact of the introduction of the IVA is significant, as indicated in Figure 1. In the sleep first proposal the landing day is reduced by 7 hours to only 15 working hours, and the liftoff day is extended from 16 to 22 working hours. A crew, upon landing on the moon, will probably be relatively excited, and is less likely to get a very good rest after a short than after a nominal work day. Previous experience supports this observation, and the Medical Research and Operations Directorate (MROD) at MSC has recommended that, based upon a physiological analysis, the first day on the moon should be long, rather than short (2). Lack of sleep during the first rest period would result in an increased level of fatigue on succeeding days.

It was considered important, in previous planning, to minimize the length of the final day on the surface in order to maximize crew effectiveness during liftoff and rendezvous. One of the strongest arguments for adopting the currently approved 66 hour surface timeline was to provide a rest period prior to liftoff so that the crew could be rested for one of their most critical tasks. It was suggested, at the time that plan was adopted, that an alternate plan be developed giving the crew the option to decide in real time to skip the final rest period if they were sufficiently rested. This provides timeline flexibility which is not available in the sleep first plan. The sleep first timeline does not provide any possibility for this final rest period before liftoff, and thus forces the crew to perform the difficult and exacting tasks of liftoff and rendezvous at the end of a long day which includes an EVA.

Circadian rhythm was also considered an important facet of the current 66 hour timeline when it was approved. For a July launch to Hadley (0753 EST) the rest periods of the current timeline deviate from the normal 24 hour daily cycle, calculated from launch, by +6, +4, +1, and 0 hours for the 4 days shown in the timeline in Figure 1. The sleep first timeline proposed in Figure 1 would alter this to a deviation of -3, -7, -11 and -6 hours, making it more difficult for the crew to obtain adequate rest. In addition, the extra 2 hours required for the IVA force two rest periods to be reduced from 8 hours to 7 hours. MROD continues to maintain that 8 hours is the minimum acceptable length of a rest period (2).

The sleep first timeline delays the EVA's by about 10 hours, the pros and cons of which are discussed below, and delays PC-2 by 11 hours. The delay of this plane change would reduce the amount of higher inclination orbital science obtained from the mission.

EVA CAPABILITY

One of the advantages of the sleep first proposal is that by placing EVA 1 on a short work day it can be extended to 7 hours from the 6 hours to which it was limited in the current plan due to the long touchdown day. In the sleep first plan, of course, EVA 3 is only 6 hours long versus 7 hours for the current timeline. The extra time on EVA 1, however, permits a more extensive geologic traverse earlier in the mission and thus allows the primary geologic objectives to be investigated, at least cursorily, in the first EVA. Although this increases the confidence in attaining these objectives, it is obtained by delaying EVA 1 by 10 hours. This extra time, as well as the extra depress/repress cycle required for the IVA, reduce the confidence of deploying ALSEP compared to the present plan.

Although the primary geologic objectives may be visited on EVA 1 in the sleep first plan, it is questionable whether sufficient time will be available for a thorough investigation of the area. Thus a second traverse to the same area may be required. Should this revisit not be required, a traverse could extend to a possible volcanic constructional complex to the north of the landing site which could otherwise not be examined. This would be a clear advantage of obtaining a 7 hour EVA 1.

The first use of the -7 PLSS, the first use of the LRV, and the first extension of an EVA beyond 5 hours are all planned for EVA 1 on Apollo 15. In order to obtain the geologic benefits of the sleep first plan, the crew would drive the LRV to a point 3 km distant from the LM near the end of this 7 hour EVA. This matter is worthy of serious consideration.

By reversing the EVA sequence and doing a 7 hour EVA 1 and a 6 hour EVA 3, as the modification of the sleep first plan proposes, EVA lengths are more compatible with overall consumables capabilities. Due to increasing sun angles and increasing leak rates EVA capability decreases with time. However, a disadvantage of the proposed plan is that it delays all three EVA's, with consequent higher sun angles and lower consumables margins.

TELEVISION

For a July launch to Hadley (0753 EST) touchdown will occur at 1827 EST on July 30. As is shown in Table 1, by the present lunar surface timeline all the EVA's would occur during the day or evening in this country, with all EVA's receiving prime time television coverage. Reflecting the differences in the circadian rhythm, the proposed IVA plan would result in a shift to the night and early morning hours, with the only prime time coverage being the beginning of EVA 3 in the Pacific time zone.

SUMMARY

An extra hour of reconnaissance and photo documentation of the lunar surface may result in increased scientific return from the mission and may provide an opportunity to perform some preliminary traverse planning and modification based on observation of the terrain. An evaluation must compare the benefits of a 360° preliminary view from the LM top hatch and a 180° view of the surface from the LM windows, 3 feet lower.

The value of a 7 hour EVA 1 rests primarily in the ability to sample, at least briefly, the primary geologic objectives in the first EVA and the possibility, if return to the area of primary geologic interest is not required, of sampling a constructional complex of postulated volcanic origin on EVA 3. To obtain this, one must accept a traverse extending about 3 km away from the LM at the end of an EVA which is planned, for the first time, to be more than 5 hours long, and which would involve the first use of the -7 PLSS and the LRV.

Other factors which result from the sleep first plan include a long liftoff day with a tired crew at liftoff and rendezvous, the short touchdown day with a probably excited crew that may not rest, lost of timeline flexibility, and a degraded circadian rhythm. In addition, an extra depress/repress cycle is required, all EVA's in the proposed plan occur about 10 hours later than in the present plan, and PC-2 is delayed 11 hours, with possible consequent reduction in scientific return. To fit the IVA into the 66 hour timeline also requires a reduction in the length of two sleep periods from 8 to 7 hours. The present plan results in EVA's during the day and evening hours in this country, while the proposed plan shifts the EVA's to the night and early morning.

The sleep first timeline may provide scientific benefit, but incurs operational costs. The advantages of the sleep first timeline are clear, although not overwhelming, and its disadvantages are substantial, although not prohibitive. The relative merits of each timeline must therefore be examined and a decision on which option to select should be based upon the potential gain to the mission as a whole which could be derived from either timeline.

Peter Benjamin

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Attachments
Figure 1
Table 1

REFERENCES

1. D. R. Scott, Apollo 15 Lunar Surface Timeline, MSC Memorandum for Record, November 9, 1970.

2. G. F. Humbert, presentation at December 2, 1970 Lunar Surface Operations Meeting.

Figure 1 - **LUNAR SURFACE TIMELINE (65.5 HR)**

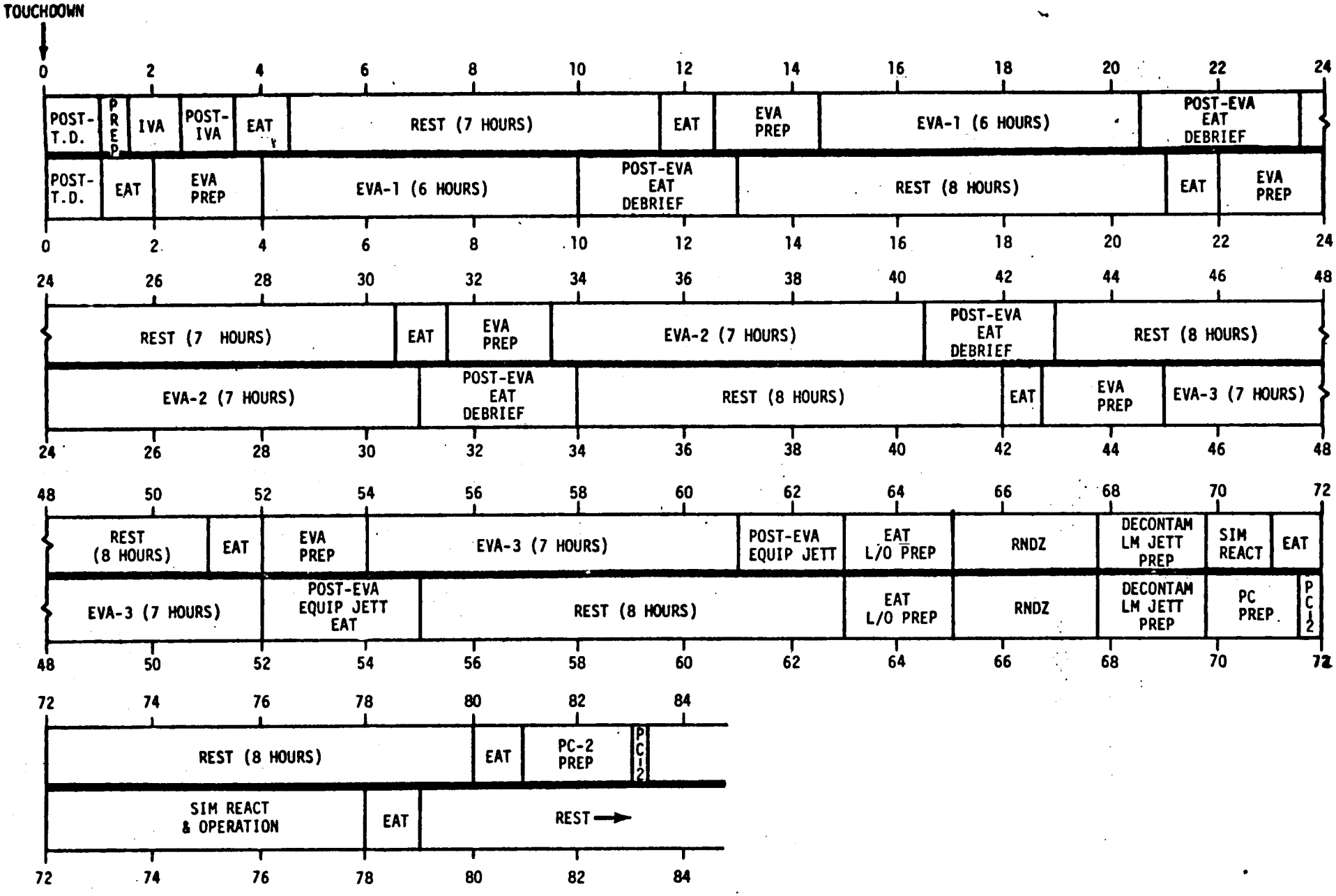

TABLE 1 - EVA SCHEDULE

	Present Plan (EVA first)	Proposed Plan (Sleep first)
EVA 1	2230-0430 EST 1930-0130 PST July 30	0900-1600 EST 0600-1300 PST July 31
EVA 2	1830-0130 EST 1530-2230 PST July 31	0400-1100 EST 0100-0800 PST August 1
EVA 3	1530-2230 EST 1230-1930 PST August 1	2430-0630 EST 2130-0330 PST August 1

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